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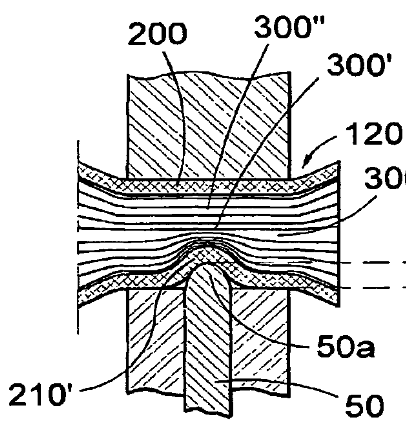
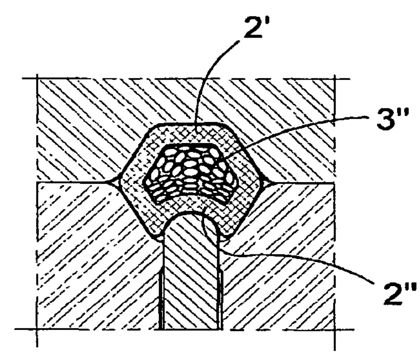
**(54) Title:** METHOD FOR CRIMPING A CONTACT MEANS TO A MULTI-THREAD CONDUCTOR AND A CRIMPING TOOL HEREFOR





**(57) Abstract:** The present invention relates to a crimping method and to a crimping tool that includes two or more reciprocatingly moveable crimping jaws adapted to establish a union or connection between a sleeve (2) and one end part of a multithread conductor, wherein the tool includes first means (10) functioning to allow the crimping jaws (4, 5) to be moved into engagement with the sleeve (2) with one end part (3) of the conductor inserted in said sleeve, so as to crimp the sleeve around the end part (3) of the conductor. The crimping jaws (4, 5) are designed to be moved by a first means (101) into "tight" co-action with each other while surrounding the sleeve (2), in a first crimping sequence (P1). The shape of the recess (40) formed by the crimping jaws in this position, the sleeve-like formation, and the end part (3) of the conductor are mutually so adapted as not only to compress the sleeve formation (20) in said "tightly" co-acting state but also the end part of the conductor (30) so as to impart to said multi-thread end part a chosen degree of compaction and deformation. The crimping tool includes a second means (102, 50) which functions to impart to the sleeve (20) and to said end part (30') a second degree of compaction and deformation over and above said first degree of compaction and deformation, in a following second crimping sequence.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# METHOD FOR CRIMPING A CONTACT MEANS TO A MULTI-THREAD CONDUCTOR AND A CRIMPING TOOL THEREFOR

## *Field of invention*

The present invention relates generally, and primarily, to a method of joining an electric contact device or connecting element or union to an end-part of a multi-thread conductor with the aid of a number of clamping or crimping jaws, both in an electrical and in a mechanical respect, wherein said device or union has the form of a sleeve.

More particularly, the present invention is based on a method in which the crimping jaws can be displaced relative to and towards each other with said sleeve placed between the jaws and with the end-part of the conductor inserted into said sleeve.

The relative movement of the jaws is adapted to cause the sleeve to be compressed against and around the end-part of the conductor during a first crimping sequence, and also to compress the compressed sleeve and the end-part of the conductor such as to obtain relatively good mechanical strength and a relatively low electrical transition resistance between conductor and sleeve within the connection or union.

Secondly, the invention relates to a crimping tool, which includes functionally two or more crimping jaws, which can be moved towards and away from each other with the aid of tool-associated first means.

The crimping tool shall be adapted to join an electric contact device or a connecting element to at least one end-part of a multi-thread conductor, said device or said element having a sleeve-like form.

The crimping tool includes and/or co-acts with said first means in a manner to enable at least one of said jaws to be moved against said sleeve with the aid of said first means, with the end-part of the conductor inserted into the sleeve, such as to compress the sleeve initially more or less uniformly around said end-part of the conductor and therewith create mechanical co-action between the sleeve and the end-part of the conductor and thus achieve relatively good mechanical strength and electric co-action with relatively low electrical transition resistance between the individual threads of the conductor and between said conductor end-part and said sleeve.

In addition, at least one crimping jaw, normally two crimping jaws, have a shape so that when in full co-action with the sleeve and when brought together the jaws will define a recess or aperture whose internal shape corresponds to an outer shape of a compressed and deformed sleeve with the end-part of the conductor enclosed therein.

***Description of the background art***

Various methods are known to the art with which at least one sleeve-formed electric contact device or a mechanical connecting element can be joined to one end-part of a multi-thread conductor in both an electrical and a mechanical respect, with the aid of a number of crimping jaws that can be displaced relative to and against each other with the one end-part of the conductor inserted in the sleeve and the sleeve placed between the crimping jaws, wherein said relative movement of the jaws is adapted so that the sleeve will be compressed initially around the end-part of said conductor and, in addition, to create further compression of the sleeve and the conductor end-part.

With "good" mechanical strength and by mechanical union of a sleeve with the end-part of a conductor there will be obtained mechanical co-action that could provide requisite and selected mechanical strength, such as to provide a chosen tensile strength, for example.

Endeavours have also been made to create this condition, and the technical deliberations associated with this technical effect would appear to reside in an attempt to create conditions, in which all threads of the conductor can be compressed uniformly.

By being able to obtain a "low" electrical transition resistance in an electrical aspect, partly between the individual threads in said end-part of the conductor, and partly between the end-part of the conductor and the sleeve, requires the application of particular measures and particular deliberations based on experience.

It would also seem that efforts to create this condition and to make the technical deliberations associated with this technical effect have involved attempts to create conditions, in which all threads in the conductor will be deformed, at least partially, with the aid of strong plastic flow of the material concerned, so that at least the thread material and the sleeve material will fuse together to achieve pronounced material homogeneity.

It is known that it is extremely difficult to obtain well adapted co-action between the measures required to achieve said “good” mechanical strength and the measures required to obtain the “low” transition resistance, since the measures taken to enhance mechanical strength conflict with the measures taken to further reduce the transition resistance.

It is also known to design different co-ordinated crimping jaws in a crimping tool so that a sleeve and an end-part of a multi-thread conductor can be joined in one single crimping sequence, in which said sequence is terminated, hopefully, with fully closed jaws (see Figure 1).

It is also known to design different co-ordinated crimping jaws in a crimping tool so that a sleeve and the end-part of a multi-thread conductor can be joined in one single crimping sequence, which shall be terminated with side-orientated “open” crimping jaws (see Figure 2).

With regard to the crimping tool, shown in Figure 2, with which one single crimping sequence is applied, hereinafter designated a first crimping sequence, practical experiences have shown that the crimping tool must be designed so that when the jaws are brought together, there will be defined an aperture that can be adapted by chosen different geometries to fulfil different requirements relating to electrical transition resistance between the end-part of the conductor and the sleeve, and good mechanical strength in the union there between.

It is also known that strenuous efforts have been made to find a technical development that would result in the ability to create conditions with the aid of simple means and/or measures that would enable this mechanical strength to be improved without also reducing the electrical transition resistance between the end-part of the conductor and without needing to use a flux, oxide degradation paste or any other substance liable to deleteriously affect the transition resistance.

It is also known to design the crimping tool and its crimping jaws in accordance with the chosen sleeve material and the chosen material of the different conductor threads and said end-part, where the material chosen in both cases may be the same but also different.

For example, it is known to make the sleeve and the conductor from copper and/or copper alloys, aluminium and/or aluminium alloys, and to choose the material and structure, such as multi-thread structure, of the conductor and the threads in accordance with the interior and exterior shape of the sleeve.

With simplification in mind, the invention will be illustrated in the following description with reference to the use of a sleeve made of copper and/or a copper based alloy, and a multi-thread conductor made of copper and/or a copper based alloy, one end-part of which conductor is inserted into the sleeve. The sleeve has a circular cross-section and has the form of a hollow annular cylinder.

In this respect, it can be considered standard to allow one end-part of a cable conductor to be exposed, e.g. by removing the insulation part, among other things.

In the case of this exemplified use application, it is known to join the sleeve to one end-part of the conductor inserted into the sleeve in one single crimping sequence, wherein primary deformation, first deformation, such as squeezing, compression, material flow and/or compaction of the sleeve on the one hand and the sleeve and the end-part of the conductor on the other hand with the aid of a first means creates a first plastic deformation through the medium of plastic flow of the materials.

Experience with regard to this single crimping sequence has shown that “good” mechanical strength and “low” electrical transient resistance between conductor and sleeve is achieved only when the crimping jaws are dimensioned “optimally” and when a sleeve surrounding aperture or recess is provided.

It is also known that the deformation forces and compression forces acting on the sleeve material and on the end-part of the conductor giving rise to said plastic deformation and plastic flow of said material have a complex structure and can best be considered as force components that are orientated in a right-angled three-dimensional co-ordinate system.

Practical experiences show that the resultant plastic flow of the sleeve material and the material of said end-part of the conductor are directed in the longitudinal and cross-directions of the sleeve and conductor.

Earlier known methods and different designs of the crimping tool and crimping jaws intended for the aforesaid use application, however, have been found to create an electric and mechanical union between the sleeve and the end-part of the conductor which results, in many cases, in different plastic flows of the material as seen in the cross-section of the conductor, since several threads are torn away while other threads fail to obtain the requisite electrical connection and thereby also fail to provide an expedient mechanical connection.

It has been found that the method comprising a single crimping sequence and using one or more studs on the crimping jaws results in a plastic flow of the materials of such magnitude as to satisfy the requirement of a low transition resistance between conductor and sleeve on the one hand, although at the cost of a reduction in a good mechanical strength. The mechanical strength achieved is, nevertheless, fully sufficient in the case of many practical applications.

It is obvious, however, that unless the plastic flow of material is restricted, some threads will be torn off and consequently not all of the threads can be used to a sufficient extent to transmit the electric current, wherewith the transition resistance will be higher than when all threads are kept intact.

The production of such electrical and mechanical unions in which sleeve and end-part of a multi-thread conductor have been joined in one single crimping sequence through the medium of mutually opposite crimping jaws has also brought about significant difficulties in being able to bring the jaws into a “tight” co-acting position, such as to enhance the compression forces that act on said sleeve and said end-part but by displacement of the crimping jaws.

Such a crimping sequence will utilise crimping jaws which, when in a tightly co-acting position, present an aperture or recess whose enclosed surface shall correspond directly to the outer surface of a finished or completed union

It is therefore desirable to use a sleeve that includes a hole, which is adapted and dimensioned to readily embrace the end-part of the conductor.

In this regard, it is desirable to provide a hole of such size as to enable the end-part of the conductor to be easily inserted thereinto. This solution allows or requires an air space, which, unfortunately, requires greater deformation than when the hole in the sleeve and the end-part of the conductor mutually co-act with a “press fit” and therewith present a small air space between the threads for example.

However, this necessary over-dimensioning of the outer and inner measurements of the sleeve has shown that the material in the outer part of the sleeve will penetrate out between mutually facing flat surface portions of the crimping jaws during the deformation sequence and therewith leave one or more, outwardly projecting, sharp edges in the longitudinal direction of the sleeve, these sharp edges being referred to as “burrs” in the following description.

The fact that the crimping jaws are unable to take a desired tight position relative to one another means that the aperture or opening obtained will be slightly greater than the optimally dimensioned aperture and therewith reduce the deformation desired, normally with a lower mechanical strength than would be desired and a higher electrical transition resistance that would be desired.

In addition, it is necessary to mechanically smooth down the rough edges or the "burrs" in an additional working process, not only to lessen and/or eliminate the risk of cuts or other injuries in the handling process, but also to eliminate corona effects and electric spark-over and to provide good insulating possibilities in general.

It is also known that the initial value obtained with respect to the transition resistance tends to increase over time, depending on the environment.

This increase is believed to be primarily due to the formation of oxide layers or other corrosion products within a union that is effected in and around poor metallic contact points. This increase in the transition resistance can be considered to be greatly dependent on external environmental conditions.

Also belonging to the earlier standpoint of techniques is the significant realisation utilised by the invention that when a copper material of given hardness is subjected to a plastic cold working and deformation, the resultant copper material will be harder than the initial copper material.

## ***Summary of the present invention***

<u>Technical problems</u>

When taking into consideration the technical deliberations that a person skilled in this particular art must make in order to provide a solution to one or more technical problems that he/she encounters, it will be seen that on the one hand it is necessary initially to realise the measures and/or the sequence of measures that must be undertaken to this end, and on the other hand to realise which means is/are required in solving one or more of said problems. On this basis, it will be evident that the technical problems listed below are highly relevant to the development of the present invention.

When considering the state of the prior art as described above, it will be seen that a technical problem resides in the ability to provide a method and a crimping tool that can be used in accordance with the method and that comprises crimping

jaws, where a transition resistance occurring between a sleeve used in the connection or union with a multi-thread conductor can be reduced effectively in relation to known techniques in this field, although while retaining the conditions stated in the introduction with respect to achieving at least good mechanical strength between the sleeve and the end-part of the multi-thread conductor.

Another technical problem resides in the ability to create conditions in respect of contact crimping, which will enable a durable reduction in the transition resistance and its resistance value to be achieved, with this reduction at least exceeding a value of 20% of the resistance value that can be achieved with known contact crimping methods of the kind mentioned in the introduction, under the proviso that good mechanical strength can be ensured at the same time.

Another technical problem resides in the ability to realise the significance of and the advantages afforded by creating conditions which will enable good metallic contact, as uniformly as possible, both from an electric and a mechanical aspect, partly between the individual threads of the conductor and partly between said threads and a sleeve included in the union or connection, during a first crimping sequence and a first deformation sequence.

Another technical problem resides in the ability to create such conditions and to realise the significance of and the advantages afforded by being able to provide a reduction in an earlier known low electric transition resistance between the individual threads of the conductor and the threads and sleeve of said conductor in addition to improving the earlier known good mechanical strength, with the aid of a special crimping process, comprising off two mutually separate crimping sequences.

Another technical problem resides in the ability to realise the significance of and the advantages afforded by a continuing deformation of the sleeve and the end-parts of respective threads of the conductor during said first crimping sequence and a first deformation process to a state in which good, or essentially good, mechanical strength and a low, or essentially, low transition resistance is achieved, and to create conditions in which an improved mechanical strength and a reduced, low transition resistance between sleeve and conductors and its individual threads is achieved during a second crimping sequence and a second deformation process, by means of local impressions or indentations that result in limited local indentation and limited local forming of a compressed sleeve and

limited local compression of the sleeve-surrounded conductor end-part at its thread section.

In respect of a combination of reduced transition resistance and fulfilment of the requirement to obtain good, and preferably improve, mechanical strength, it will be seen that a technical problem resides in the creation of conditions which enable the crimping jaws to be brought so "tightly" adjacent one another as to eliminate the formation of sharp edges or "burrs" on the outer surface of the sleeve, therewith obviating the need to subsequently treat and work said surface mechanically.

It will also be seen that a technical problem resides in the ability to form a connection or union that can be considered to fulfil high anti-corrosion requirements and high resistance to environmental influences over long periods of time.

In addition, a technical problem resides in the ability to realise the significance of and the advantages afforded by adapting a first of said two crimping sequences to primarily compress and deform the sleeve against the conductor end-part and at least a peripheral area of said end-part, and, in addition, to compress the sleeve and said peripheral area against the "burr" formation border and thereafter allow a second crimping sequence and deformation process to take place within and through a delimited, local region of the sleeve and in towards a delimited region of said conductor end-part, therewith to create conditions for achieving said first and said second deformation process sequentially.

It will also be seen that a technical problem resides in the ability to realise the significance of and the advantages afforded by initialising and effecting said second deformation process while retaining the pressure forces acting in the sleeve and on the conductor end-part from the first deformation process.

Another technical problem resides in the ability to realise the significance of and the advantages afforded by creating during said first compression sequence and said first deformation process conditions which will enable the crimping jaws to be moved to a position in which they mutually co-act with sufficient "tightness" to initialise plastic deformation of the sleeve and the conductor end-part during said first compression sequence, and also to create conditions with respect to the crimping jaws such as to enable the jaws to surround the sleeve and the conductor in a position in which the jaws lie "tightly" together while retaining high pressures in the absence of "burrs" formation.

Another technical problem resides in the ability to realise the significance of and the advantages afforded by causing a first deformation resulting from a chosen first crimping sequence to be only slightly less than the deformation that would cause the peripheral material of the sleeve to flow plastically out between the crimping jaws.

Another technical problem resides in the ability to realise the significance of and the advantages afforded by deforming the sleeve and the end-part of the conductor in a second compression sequence to a chosen lesser extent than the deformation achieved by the first deformation process, as the crimping jaws are in said mutually "tight" co-acting position.

Another technical problem resides in the ability to realise the significance of and the advantages afforded by creating an electrical and a mechanical crimped union or connection between a sleeve and one end-part of the conductor, where an extension in the length of the sleeve caused by one of the pressure forces in the second crimping sequence can be reduced with the aid of crimping jaws that fully surround the sleeve, under other similar known conditions.

Another technical problem resides in the ability to provide measures whereby said second deformation is achieved with the aid of a so-called drift, wherewith a limited local impression and shape-change of the already deformed sleeve is obtained, and wherewith compression of thread sections close to the jaws is obtained by centred plastic deformation, said drift including a penetrating point, a hemispherical shape or a semi-ellipsoidal shape or some other correspondingly rounded shapes.

Another technical problem resides in the ability to realise the significance of and the advantages afforded by utilising during the second compression sequence and the second deformation process those frictional forces that will be active between the outer surface and the mutually parallel surface portions of the jaws and the inner surface of the sleeve, the end-part of the conductor, and the thread section forming said end-part with the aid of the first compression sequence and the deformation caused thereby, so as to limit the extension of the sleeve in its longitudinal direction and in the longitudinal direction of the conductor to some extent.

## <u>Solution</u>

There is proposed, in accordance with the invention, a method of establishing a union or connection between at least one sleeve and one end-part of a multi-thread conductor, from both an electrical and a mechanical aspect. The invention also relates to a crimping tool that includes compression jaws adapted for carrying out the method.

Both the method and the tool are based on achieving a pressed or crimped connection or crimped union or connection with the aid of pressure jaws or crimping jaws, in the simplest case one movable jaw and one fixed jaw, wherein the jaws can be displaced relative to and against one another with the sleeve and one end-part of the conductor placed in the sleeve positioned between the jaws, and wherein the relative movement of the jaws is adapted to initially compress the sleeve around the end-part of the conductor and thereafter to further compress said compressed sleeve and the end-part of the conductor during a first compression or crimping sequence, so as to achieve a desired (good) mechanical strength and a desired (low) electric transient resistance between conductor and sleeve through the medium of a first deformation process.

With the intention of solving one or more of the aforesaid technical problems, it is proposed, in accordance with the invention, that the jaws can be moved during said first compression sequence to a position in which said jaws can be considered to co-act "tightly" with one another such as to obtain a first deformation and such as to define in said position, in which said jaws have been brought "tightly" together, an aperture or opening that surrounds the thus compressed sleeve and the one end-part of the conductor positioned in said sleeve, therewith achieving said first deformation.

It is also proposed that while maintaining said first deformation a part of the sleeve and one end-part of the conductor will be given a second deformation via a second crimping sequence, so as to further enhance the mechanical strength and further reduce the electrical transient resistance.

By way of proposed embodiments, it is also suggested that the tight co-action between the jaws is adapted to enable the first deformation process to be effected without the formation of "burrs" on the sleeve material located between the jaws, and that the first crimping sequence shall be completed totally prior to initialising and commencing the second crimping sequence. The first crimping sequence

shall at least be almost completed prior to initialising and commencing the second crimping sequence.

It is also proposed that during said first crimping sequence, the sleeve shall deform the threads in the end-part of the conductor contained in the sleeve to a state that continues essentially through the entire cross-section of the material of said threads.

It is also proposed that during said second crimping sequence, there is created a limited local indentation or impression and a limited local shaping of the sleeve, and a limited local compression of the end-part of the conductor and its thread section surrounded by the sleeve.

A reduction in area of below 50% of the width of the jaws or of the extension of the conductor in its longitudinal direction may be chosen.

The second crimping sequence may conveniently be effected with the aid of a so-called drift or mandrel having a rounded tip, such as a hemi-spherical tip or a semi-ellipsoidal tip or a tip of some corresponding shape.

The major and minor axes of the ellipsoidal will preferably have a ratio smaller than 2, such as a ratio of 1.6 to 1.1.

When the threads or wires in the conductor have a circular cross-sectional shape, the first crimping sequence and the first deformation formed thereby is chosen so that in respect of a chosen cross-section of a sleeve portion positioned between the jaws, the free space between the threads will be smaller than 10% of the cross-sectional surface of the thread portion.

In the case of a pre-compacted and selected cross-section of the conductor threads, the first crimping sequence and the resultant first deformation are such that in respect of a chosen cross-section of a sleeve portion orientated between the jaws, the space between the threads will be less than 4% of the cross-sectional surface of the threads.

It is also proposed that the free space between the threads is reduced by at least a further 25% during the second crimping sequence.

The first crimping sequence and the resultant first deformation, and the second crimping sequence and the resultant second deformation are adapted so as to provide equivalent or at least essentially equivalent mechanical properties as those achieved with the known technology in respect of a chosen pressure geometry relating to the sleeve and the end-part of the conductor and in addition

also to reduce the transition resistance by at least 20% in relation to those values corresponding to known transition resistances.

Advantages

Those advantages that can be considered significant to a method and a crimping tool, according to the present invention, reside in the creation of conditions which enable sharp press edges in the form of "burrs" on the outside of the connecting element or sleeve to be avoided, and also the creation of conditions which will enhance corrosion resistance, and also which will enhance properties relating to a low electrical resistance and a lower electrical resistance across the connection within said union while still achieving good, and preferably improved mechanical strength.

These improved properties are obtained by compressing the sleeve and the end-part of the conductor in two sequential crimping sequences, in which the sleeve is subjected to a first plastic deformation process distributed over the end-part of the conductor in a first crimping sequence, and further deformation of said end-part, where a second locally acting crimping sequence shall create the final union or connection, with an adapted low, and preferably lower, transition resistance while retaining high, and preferably improved, mechanical strength.

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The primary characteristic features of the inventive method are set forth in the characterising clause of the accompanying Claim 1, while the characteristic features of an inventive crimping tool are set forth in the characterising clause of the accompanying Claim 14.

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***Brief description of the drawings***

A number of earlier known electrical and mechanical connections where a sleeve and a multi-thread conductor are joined together in a union or connection with the aid of a single crimping sequence, and the manufacture of an electrical and mechanical union or connection where a sleeve and the end-part of a multi-thread conductor are united through the medium of a first and a second crimping sequence, in accordance with the inventive concept, will now be described in more detail, by way of example and with reference to the accompanying drawings, in which;

**Figure 1** shows on the left a slightly enlarged cross-sectional view of an earlier known electrical and mechanical union or connection, where a sleeve and an end-part of a multi-thread conductor have been united in one single crimping sequence, with the aid of mutually opposed crimping jaws, said jaws being shown in perspective in a fully open position on the right of Figure 1;

**Figure 2** shows on the left a slightly enlarged cross-sectional view of an earlier known electrical and mechanical connection, where a sleeve and the end-part of a multi-thread conductor have been joined together in one single crimping sequence with the aid of mutually opposed crimping jaws, which are shown in perspective in a fully open position on the right of Figure 2;

**Figure 3** is a cross-sectional view of an earlier known electrical and mechanical union or connection produced by crimping jaws of the type shown in Figure 1;

**Figure 4** shows a side sectional view and a cross-sectional view of a first jaw position in the production of an electrical and mechanical union or connection in accordance with the invention;

**Figure 5** shows a side sectional view and a cross-sectional view of a deformed sleeve and the end-part of a multi-thread conductor joined to said sleeve by means of a first crimping sequence;

**Figure 6** shows the deformed sleeve and the end-part of the multi-thread conductor united by means of a second crimping sequence; and

**Figure 7** is a graph illustrating the time-wise variation of the pressure forces and the deformation during said two crimping sequences.

***Description of prior art techniques according to Figures 1, 2 and 3***

Figure 1 thus illustrates a known first embodiment that comprises two crimping jaws or press jaws, i.e. a first jaw 4 that includes one-half of an hexagonal recess 4a, and a second jaw 5 that includes the other half of an hexagonal recess 5a, said jaws being dimensioned to obtain a pressure connection 1 of symmetrical hexagonal cross-section in one single crimping sequence.

Each of the jaws is provided with a centrally positioned bead 4b, 5b, which are intended to be pressed into a hollow cylindrical sleeve 2 during said crimping sequence, at the commencement of said sequence, and therewith press the

threads in the conductor 3 together, resulting in a plastic deformation at least in a direction towards the central region of the pressed connection.

It will be noted that in the following description the reference numeral 2 has been reserved for a hollow cylindrical and transversely circular sleeve, where subsequent to a first deformation the sleeve is referenced 20.

Similarly, the reference numeral 3 has been reserved for a multi-thread conductor, which is referenced 30 subsequent to said first deformation.

The beads 4b and 5b respectively are intended to make small local impressions or indentations 20a, 20b in the sleeve 20, and also contribute towards plastic deformation of the conductor 30 within a local central area.

In the illustrated case, the plastic deformation is intended to surround a chosen length of the sleeve 2 between parallel surfaces 4a, 5a, where said length may be the full length of the sleeve 2 or at least a predominant part of said length.

The jaws 4, 5 have been given a length "L1" to this end.

As the circular sleeve is deformed plastically to an hexagonal cross-sectional shape, according to Figure 1, the sleeve material within the diametrical outer regions of the sleeve will flow out plastically between mutually opposite surfaces 4c and 5c during one single crimping sequence, therewith forming "burrs" 22, 23, which must be removed by a separate mechanical working process for several practical reasons.

In this regard, it is necessary that the surfaces 4c, 5c tightly abut one another at the end of the deformation process, so that the crimped union or connection 1 can exhibit the desired good mechanical strength and the desired low electrical transition resistance.

When the jaws 4, 5 are fully closed, there is formed an "aperture" or hole 40 whose internal shape functions to press the sleeve 2 into a chosen outer shape 20', in the illustrated case an hexagonal shape.

A second known design for providing a press connection 1' by means of one single crimping sequence is shown in Figure 2, which illustrates the use of two ridge portions 4e', 4d' on an upper crimping jaw 4', these ridges being intended for abutment with a hollow cylindrical sleeve (2) resting in a partly cylindrical recess 5d' in the jaw 5'.

The requisite plastic deformation of the sleeve 20' and the associated plastic deformation of the conductor 30' is achieved by pressing the material of the end-

part of the conductor to a more or less homogenous structure during one single crimping sequence, with forced plastic flow of the material in the longitudinal extension of the conductor and the sleeve and "free" plastic flow in the cross direction or extension of the conductor and the sleeve, by virtue of not bringing the jaws 4', 5' into a tight position and therewith eliminate the formation of "burrs".

There is nothing to prevent a bead 5e' being provided in the jaw 5' also in this case.

Designs, according to Figure 2 and similar designs, have been found to produce undesired concentrated deformation and a friction effect between the individual threads in the conductor 30' within the sleeve 20', and also that they result in an extremely large concentrated reduction in area of the conductor 30'. There are good reasons for supposing that the design illustrated in Figure 2 will provide a press connection of reduced mechanical strength properties although with a very low transition resistance.

The cross-sectional shape shown in Figure 3 is produced in a single press sequence in the same way, with the jaws 4, 5 configured in accordance with Figure 1. It will be understood how the crimping jaws shall be shaped more specifically with regard to the recesses 4a and 5a. "Burrs" 22, 23 also occur in this case.

A common feature of the tool designs illustrated in Figures 1, 2 and 3 is that they cannot be readily optimised to obtain contact pressing with high demands on a low transition resistance value and on a high mechanical and environmental properties.

Thus, "burrs" 22, 23 can be formed with the designs according to Figures 1 and 3, since the jaws 4 and 5 do not bring the surfaces 4c and 5c into a fully closed and tight position prior to limited plastic flow of material out between the jaw surfaces 4c, 5c during plastic deformation of the sleeve.

Moreover, longitudinal stretching of the conductor 30 together with and relative to the sleeve 20 causes some threads to be stretched beyond their yield points and therewith tear off certain threads, thereby impairing electrical and mechanical properties.

It will also be apparent that a very accurate balance must be made between a number of different factors, with regard to the dimensioning of the jaw recesses,

the size of the beads and their position in the recess, the chosen shape of the recess, and the dimensioning of sleeve and conductor treated in said recess.

***Description of embodiments at present preferred***

It is pointed out initially that we have chosen to use in the following description of embodiments at present preferred and including significant characteristic features of the invention and illustrated in the figures of the accompanying drawings special terms and terminology with the intention of illustrating the inventive concept more clearly.

However, it will be noted that the expressions chosen here shall not be seen as limited solely to the chosen terms used in the description but that each term chosen shall be interpreted as also including all technical equivalents that function in the same or at least essentially the same way so as to achieve the same or essentially the same intention and/or technical effect.

Thus, Figures 4 to 6 illustrate a press connection or a press union 120, produced in accordance with the principles of the invention with respect to a union or connection that includes a sleeve 2 made of copper or copper alloy, and a multi-thread conductor 3 where the individual threads consist of copper or copper alloys, wherein the sleeve and the conductor are mutually united through the medium of a unique crimping sequence, illustrated in Figures 4, 5 and 6.

As before mentioned, Figure 4 is a side sectioned view on the left-hand side and a cross-sectional view of the sleeve 2 and the conductor 3 on the right-hand side, said sleeve and conductor being shown in a mutually co-acting position with the jaws 4, 5 shown in a fully open position. Figure 5 is a similar illustration of a deformed sleeve 20 and conductor 30 compressed during a first crimping or pressing sequence, and Figure 6 shows an additionally deformed sleeve 200 and conductor 300, which have been locally compressed during a second crimping sequence.

Although the same reference signs have been allocated to Figures 1 and 5, it will be noted that the deformation shown in Figure 5 is slightly smaller than the deformation indicated in Figures 1 and 3.

With regard to an embodiment proposed at present and described hereinafter, it can be mentioned that a good result has been achieved in respect of a

cross-sectional shape of the press union or connection 120 when a circular sleeve 2 has been pressed to an hexagonal cross-sectional shape.

Shown in Figures 4 to 6 is a sequence comprising several steps (three) for producing an electrical and mechanical press union or connection 120, where a sleeve and a multi-thread conductor have been mutually united in respective stages 2, 20, 200 and 3, 30, 300, with the aid of a mutually sequential first and second crimping sequences and first and second deformations related thereto.

Figure 4 illustrates how a sleeve 2 of circular cross-section and included in a union 12 loosely surrounds one stripped end-part 3' of a conductor 3. The sleeve 2 containing conductor 3 is shown inserted between the two open crimping jaws 4 and 5.

The sleeve 2 of the illustrated embodiment has a circular, annular cross-sectional shape and the shape and choice of material are adapted to the cable or conductor used, the conductor material and the thread structure within the conductor 3 in a known manner.

In the case of the illustrated embodiments, the jaws 4, 5 have an opening formed by co-ordinated grooves 4a, 5a, whose shapes are such as to provide a union 120, in which the sleeve 200 has an hexagonal outer cross-section, as shown in Figure 6.

In Figure 5, the jaws 4, 5 have been displaced during a first crimping sequence to a position in which the jaw surfaces 4c and 5c tightly co-act with each other, such as to surround a sleeve 20 formed by plastic flow of material and therewith form the outer hexagonal shape 20' desired of the outer sleeve surface in the finished union 120.

In this respect, it is necessary to limit the internal pressure and the internal force that act from the compressed and compacted end-part 30' of the multi-thread conductor 30 and caused by plastic flow occurring in the sleeve 20, so that a surrounding outer part of the sleeve material will not tend to flow out between mutually facing jaw surfaces 4c, 5c such as to form “burrs”.

It will be understood that the expression “tight” as used in this document does not solely mean purely mechanical contact between the surfaces 4c, 5c but also a state or position in which said surfaces 4c, 5c are spaced apart by a distance which is so small as to fully prevent the formation of “burrs”.

In the case of the illustrated embodiment, the jaws 4, 5 are mirror images of one another, wherein the jaw 5, includes a recess 4a for co-action with the recess 5a of the sleeve 2.

The two co-acting recesses 4a, 5a not only function to compress and deform the outer shape of the sleeve 2 to the desired external hexagonal shape 20' when the jaws are in a tight mutually co-acting position (Figure 5), but also to deform and compress at least the periphery section of the end-part 30' of the conductor 30 and therewith also impart to the multi-thread end-part 30' a desired degree of compaction or a desired reduction in cross-sectional area.

Deformation within the end-part 30' will conveniently be as high as possible without diametrically opposite sleeve material being seen to flow out between the jaw surfaces 4c, 5c.

This first degree of compaction or deformation may sometimes be sufficient to provide an acceptable mechanical strength and an acceptable low electric transition resistance between the sleeve 20 and said one end-part 30' of the multi-thread conductor.

The first degree of compaction shall at least be of such high magnitude and the deformation shall be driven to an extent such as to provide crimping and fixed desired orientation of the threads in the end-part 30'.

In the case of certain applications, it is a matter of being able to obtain at least essentially parallel orientation of the threads 30" within the end-part 30' located in the sleeve 20.

It is also proposed, in accordance with the invention, that the first degree of compaction or deformation shall be adapted so that at least the total material of the sleeve 2 shall be formed by occurring forces that cause said material to pass beyond its flow limit or yield point, so as to form the external hexagonal surface 20' on the sleeve via said plastic deformation.

In this state, one end-part 30' of the multi-thread conductor 30 will be compacted and deformed and embraced by the deformed sleeve 20 crimped thereon.

This compression or crimping of the cylindrical sleeve 2 to its hexagonal shape 20 and subsequent compression and deformation of the end-part 30 of the conductor are shown in Figure 5.

As the jaws 4, 5 take a “tight” co-acting position in which they embrace the sleeve 20 and maintain the forces acting on and within said sleeve (according to Figure 5), the sleeve 20 and the end-part 30’ of the conductor are now subjected to a second crimping sequence or deformation process (according to Figure 6) which is greater than the deformation achieved in the first deformation process.

This is achieved with the aid of a drift or mandrel 50, which is caused to deform the sleeve 20 within a delimited surface part 210 thereof, wherein as a result of the initial shape change, the sleeve 20 has a limited tendency to expand longitudinally or to move longitudinally, at the same time as the drift or mandrel 50 imparts to the already deformed sleeve 20 a centred and local indentation or shape change 210’ and further compresses said one end-part 300’ of the multi-thread conductor.

This second degree of deformation is sufficient to homogenise at least partially a delimited section within said one end-part 300’ of the multi-thread conductor 300, so as to establish effective electrical contact between the various threads 300” of the conductor 300 in said end-part 300’ and between the conductor threads and the sleeve 200 while, at the same time, avoiding impairment of the mechanical strength of the union or connection.

Thus, during the first compression sequence or deformation process the sleeve 2 and the threads 3” in the end-part 3’ inserted in the sleeve are pressed together by mutually parallel surface parts 4a’, 5a’ of the jaws 4, 5, it being noted that these surface parts define an opening 40 that has plane-parallel surfaces which are fully open outwards (in the longitudinal direction of the conductor 3).

It is also conceivable, however, to provide the jaws 4, 5 with sleeve-related edges so as to enable plastic flow of the material to be further reduced by said edges in the longitudinal direction of the conductor 30 and the sleeve 20 during said second deformation process.

This second deformation process is effected via a locally delimited indentation or impression of the surface part 210 of the sleeve 20 and further local compression of the thread section 30” by means of a drift or mandrel 50 that has a rounded tip, preferably a tip of circular cross-section in general.

More particularly, it is proposed in accordance with the invention that when using threads 3” of circular cross-section or at least essentially of circular cross-section, the first deformation process so that it causes a uniform force of equal

magnitude acting in a direction normal to the long access of the conductor or sleeve and will constantly be found in each selected cross-section.

The second deformation process is effected so that the material will be homogenised, at least in chosen parts of the enclosed cross-sectional area.

The second deformation process will preferably be driven to an extent in which all or at least the majority of the multi-thread wires 300" in one end-part 300' of the conductor 300 will be compressed into an homogenous structure.

Referring back to Figures 4 to 6 and the sequence illustrated therein, it will be readily seen that a crimping tool 100 at present proposed will include a first piston-cylinder device 101, which functions to move the upper movable jaw 4 towards a fixed, lower jaw 5 in the first crimping sequence, and that the tool includes a second piston-cylinder device 102, which functions to carry out the second crimping sequence with the aid of a cylindrical drift or mandrel 50.

The second piston-cylinder device 102 is placed centrally of the first piston-cylinder device 101.

It can be mentioned in particular that the invention has been developed with the intention of being able to satisfy the high requirements placed on contact crimping of multi-thread flexible conductors, such as the successively increasing demands placed on such unions or connections 20.

The crimping tool 100 also enables the two piston-cylinder devices 101, 102 to be actuated by one and the same pressure.

The choice of an appropriate length "L1" of the jaws 4, 5 along the recesses 4a, 5a will enable the crimping process to be controlled so as to obtain a good effect in the second deformation process by pressing in the drift or mandrel 50.

For example, it may be appropriate to give the jaws a length "L1" and a width "B1", so that said jaws will be brought to a "tight" mutually co-acting position at a given adapted pressure wherein the second crimping sequence commences thereafter. The depth to which the drift or mandrel pierces 210' the sleeve can vary in accordance with different designs of the tip 50a of the drift or mandrel 50 and in accordance with other drift or mandrel dimensions.

The penetration depth will be limited by a mechanically determined length of stroke of the drift or mandrel.

The penetration depth "D1" achieved during the second crimping sequence or deformation process can vary between 15 and 30% of the enclosed cross-section "T1" in the first crimping sequence or first deformation process.

In respect of joins or unions 120 that include a high percentage of cable or conductor material in cross-section (35 & 95 square mm) is considered suitable to choose a higher degree of shaping or forming in the second crimping sequence.

The first crimping sequence is fully terminated by said first means 101 before the second crimping sequence (Figure 6) is initiated and commenced by said second means 102. Alternatively, the first crimping sequence may be practically completed by said first means 101 prior to initiation and commencement of the second crimping sequence by said second means 102.

During said first crimping sequence, the first means 101 deforms the sleeve 20 and the threads or wires 30" in the end-part 30' of the conductor 30 located in said sleeve, this deformation occurring essentially through the entire cross-section of the threads 30".

During the second crimping sequence, the second means 102 functions to form a locally limited impression or indentation and a locally limited shaping 210' of the sleeve (200), and local limited compression of the end-part 300' of the conductor 300 and its thread sections 300" enclosed by the sleeve.

During this second crimping sequence, said second means 102 also carries out an area reduction process, within a maximised reduction value of less than 50%.

The reduction in area may be between 30 and 40%.

The reduction in area is achieved by said second means 102 within a chosen area of less than 50% of the jaw width (B1) and/or the area reduction is achieved by said second means 102 within an area of less than 30% of the sleeve length "L1".

The second crimping sequence is carried out by said second means 120 that has the form of a drift or mandrel 50 which includes a rounded tip (50a), for example in the form of a hemi-spherical tip or a semi-ellipsoidal tip.

In this latter case, it is proposed that the ratio of the major and minor axis of the ellipsoid is smaller than 2, such as between 1.6 and 1.1.

When choosing threads 3" of circular cross-section in the conductor 3, the first crimping sequence and the resultant first deformation are adapted so that the

free space between the threads 30" in a chosen cross-section of a portion of the sleeve 20 located between the jaws will be less than 10% of the cross-sectional surface of the threads 3".

In the case of a pre-compressed and chosen cross-section of the threads 3" in the conductor 3, the first crimping sequence and the resultant first deformation are adapted so that a chosen cross-section of a portion of the sleeve 20 located between the jaws will have a free space between the threads 30" of less than 4% of the cross-sectional area of the threads 3".

It is proposed as a principle rule that the free space between the threads 3" can be deformed during the second crimping sequence at least to less than 40%, such as 10 to 30%.

The present invention allows the first crimping sequence and the resultant first deformation effected by said first means 101, and the second crimping sequence and the resultant second deformation effected by said second means 102 to be mutually so adapted in respect of a chosen crimping geometry of the sleeve and the end-part of the conductor as to provide equivalent or at least essentially equivalent mechanical properties, and to reduce the transition resistance by at least 20% in relation to those transition resistances obtained with earlier known methods.

Figure 7 is a schematic deformation/time diagram (D1t), which illustrates the time-wise variation of a contemplated deformation during said two mutually sequential crimping sequences P1 and P2.

It will be obvious that the graph can show variations for each union or connection 120.

The example illustrates a multi-thread copper conductor 3 inserted into a cylindrical copper sleeve 2 with equivalent properties.

Thus, it will be seen that successive compression and deformation of the sleeve 2 and the end-part 3' of the conductor 3 takes place during the first crimping sequence P1 to the greatest possible extent, although in the absence of "burrs" formation.

Immediately thereafter, there is carried out the second crimping sequence P2 with a locally limited compression and deformation process. During this second crimping sequence P2, the deformation obtained in the first crimping sequence P1

can be considered as being constant, since the sleeve 20 and the end-part 30' of the sleeve are enclosed between the jaws 4, 5.

Figure 7 illustrates therewith the contribution 71 from the first crimping sequence P1 that increases progressively, whereas the contribution 72 from the second crimping sequence P1 is shown to increase linearly.

It will be understood that the invention is not restricted to the aforedescribed and illustrated exemplifying embodiment thereof and that modifications can be made within the scope of the inventive concept as illustrated in the accompanying Claims.

CLAIMS

1. A method of establishing a union or connection from both an electrical and a mechanical aspect between at least one sleeve formation and one end-part of a multi-thread conductor with the aid of a number of crimping jaws, wherein said jaws are caused to move relative to and towards each other whilst said sleeve with said one end-part of the conductor inserted therein is located between the jaws, and wherein the relative movement of said jaws is adapted to compress the sleeve around the conductor end-part and to compress said compressed sleeve and the conductor end-part during a first crimping sequence such as to achieve good mechanical strength and low electric transient resistance between conductor and sleeve, **characterised** by;

a) moving the jaws during said first crimping sequence to a position in which they can be considered to co-act "tightly" with each other such as to embrace the thus compressed sleeve and the conductor end-part inserted therein in an aperture defined by the jaws when brought together, therewith effecting a first deformation of said sleeve and said end-part; and

b) imparting to a portion of the sleeve and the conductor end-part a second deformation via a second crimping sequence whilst retaining the first deformation according to "a" above, so as to further enhance the mechanical strength and further reduce the electrical transient resistance.

2. A method according to Claim 1, **characterised** by adapting the "tight" co-action between the crimping jaws so that the first deformation process will take place without the sleeve material forming "burrs" between the crimping jaws.

3. A method according to Claim 1 or 2, **characterised** by fully completing the first crimping sequence before initialising and commencing the second crimping sequence.

4. A method according to Claim 1 or 2, **characterised** by having practically completed the first crimping sequence before initialising and commencing the second crimping sequence.

5. A method according to Claim 1, **characterised** by pressing the sleeve and the threads of the conductor end-part located in said sleeve during the first crimping sequence such as to impart to said threads a deformation that occurs essentially through the entire material cross-section of said threads.

6. A method according to Claim 1, **characterised** by making a locally limited impression or indentation and effecting locally limited shaping of the sleeve during said second crimping sequence, and, in addition, imparting locally limited compression of the conductor end-part and its thread section surrounded by the sleeve.

7. A method according to Claim 6, **characterised** by reducing the free space between the threads by at least an additional 25% during said second crimping sequence.

8. A method according to Claim 1, **characterised** by carrying out an area reduction process within a chosen region, such as a centred region, so as to achieve a reduction in area in the order of under 50% of the width of the crimping jaw.

9. A method according to Claim 1, **characterised** by carrying out said second crimping sequence with the aid of a so-called drift or mandrel that has a hemi-spherical tip or a semi-ellipsoidal tip.

10. A method according to Claim 9, **characterised** by giving the major and minor axis of the ellipsoid a ratio of less than 2, such as a ratio of 1.6 to 1.1.

11. A method according to Claim 1 when the conductor threads or wires have a circular cross-section, **characterised** by carrying out the first crimping sequence and the first deformation process so that the free space between the threads in a

chosen cross-section of a portion of the sleeve located between the jaws will be less than 10% of the cross-sectional area of the threads.

12. A method according to Claim 1 in respect of a chosen pre-compacted cross-section of the conductor threads, **characterised** by carrying out the first crimping sequence and the first deformation process so that the free space between the threads will be less than 4% of the cross-sectional area of said threads in a chosen cross-section of a sleeve portion located between said crimping jaws.

13. A method according to any one of the preceding Claims, **characterised** by adapting the first crimping sequence and the resultant first deformation and the second crimping sequence and the resultant second deformation so as to obtain in respect of a chosen crimping geometry of the sleeve and the conductor end-part equivalent, or at least generally equivalent, mechanical properties for achieving a reduction in the transition resistance of at least 20% in relation to the transition resistances obtained with earlier comparable methods.

14. A crimping tool that includes two or more crimping jaws that can be moved towards and away from each other, wherein the tool is constructed for the union or connection of a sleeve with one end-part of a multi-thread conductor, wherein the tool includes first means (101), which function to move said jaws (4, 5) against said sleeve (2, 20, 200) with one end-part (3', 30', 300') inserted in said sleeve, so as to compress the sleeve around said conductor end-part, wherein at least one crimping jaw includes a recess or aperture (40) for co-action with the sleeve, wherein relative movement of the crimping jaws (4, 5) by said first means (101) causes the sleeve (2) to be compressed about the end-part (3) of the conductor, and to further compress the compressed sleeve (20) and the end-part (30') of the conductor during a first crimping sequence, wherein the crimping jaws (4, 5) are adapted to be moved during said first crimping sequence to a position (Figure 5) in which they can be considered to co-act "tightly" with each other such as to fully embrace the compressed sleeve (20) and the conductor end-part (30') inserted therein in a recess or aperture (40) defined by said crimping jaws when said jaws are brought together, therewith effecting a first deformation, **characterised** in that said tool includes second means (102), which are activated whilst maintaining said

first deformation so as to create a second crimping sequence (Figure 6), wherewith part of the sleeve (210) and one end-part (300) of the conductor are imparted a second deformation such as to further enhance the mechanical strength and further reduce the electrical transition resistance of the union or connection.

15. A crimping tool according to Claim 14, **characterised** in that the "tight" co-action between the crimping jaws is adapted so that said first deformation is achieved without the formation of "burrs" of sleeve material between the crimping jaws.

16. A crimping tool according to Claim 14 or 15, **characterised** in that said first means (101) functions to fully complete the first crimping sequence prior to initiation and commencement of the second crimping sequence by said second means (102).

17. A crimping tool according to Claim 14 or 15, **characterised** in that said first means (101) functions to practically complete the first crimping sequence prior to initiation and commencement of the second crimping sequence by said second means (102).

18. A crimping tool according to Claim 14, **characterised** in that said first means (101) functions to force pressure to be exerted on the sleeve (2) and the threads (3") of the conductor end-part inserted in said sleeve during said first crimping sequence, such as to obtain deformation essentially through the entire material cross-section of the threads (30").

19. A crimping tool according to Claim 14, **characterised** in that during said second crimping sequence the second means (102) functions to provide a locally limited indentation and a locally limited shaping (210) of the sleeve (200), and a locally limited compression (300) of the conductor end-part and its thread section enclosed by the sleeve.

20. A crimping tool according to Claim 14 or 19, **characterised** in that said second means (102) functions to force a reduction in area within a selected region, such as a centred region, of beneath 50% of the width of the jaw.

21. A crimping tool according to Claim 14, **characterised** in that said second crimping sequence is carried out by said second means (120) in the form of a so-called drift or mandrel (50) that has a rounded tip (50a), such as a hemi-spherical tip or a semi-ellipsoidal tip.

22. A crimping tool according to Claim 21, **characterised** in that the major and minor axis of the ellipsoid have a ratio of less than 2, such as a ratio between 1.6 and 1.1.

23. A crimping tool according to Claim 14, **characterised** in that in the case of a circular cross-section of the threads in the conductor (3), the first crimping sequence and the resultant first deformation are such that the free space between the threads in a chosen cross-section of a sleeve portion located between the crimping jaws will be less than 10% of the cross-sectional area of the threads.

24. A crimping tool according to Claim 14, **characterised** in that in the case of a pre-compacted and chosen cross-section of the conductor threads, the first crimping sequence and the resultant first deformation are such that the free space between the threads in a chosen cross-section of a portion of the sleeve located between the crimping jaws will be less than 4% of the cross-sectional area of the threads.

25. A crimping tool according to Claim 14, 19, 23 or 24, **characterised** in that said second means (102) functions to cause a further reduction of at least 25% in the free space between the threads during said second crimping sequence.

26. A crimping tool according to Claim 14, **characterised** in that the first crimping sequence and the resultant first deformation caused by said first means (101) and the second crimping sequence and the resultant second deformation caused by said second means (102) are mutually so adapted in respect of a chosen crimping

geometry of the sleeve and of the conductor end-part as to provide equivalent, or at least essentially equivalent, mechanical properties although at a reduction in the transition resistance of at least 20% in relation to the transition resistances obtained by earlier known crimping tools of this nature.

Fig. 1

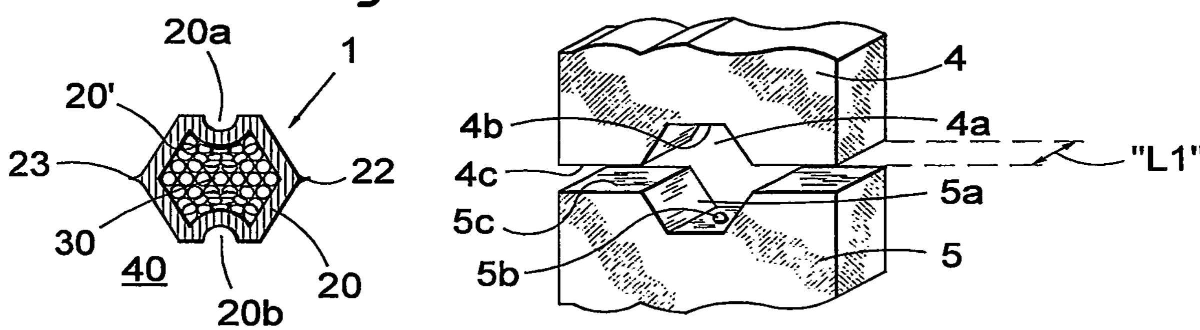



Fig. 2

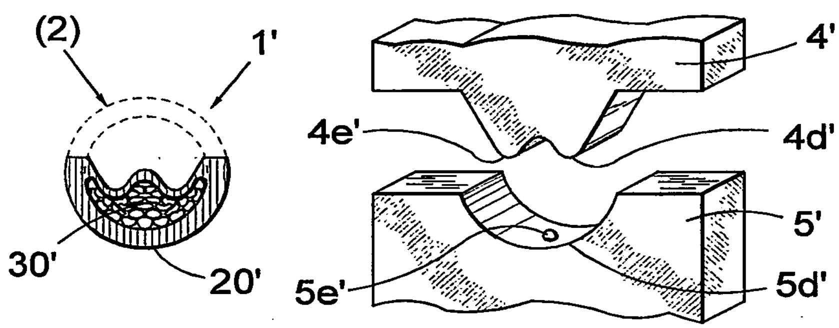



Fig. 3

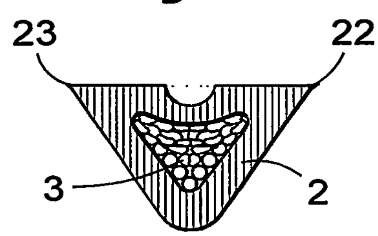
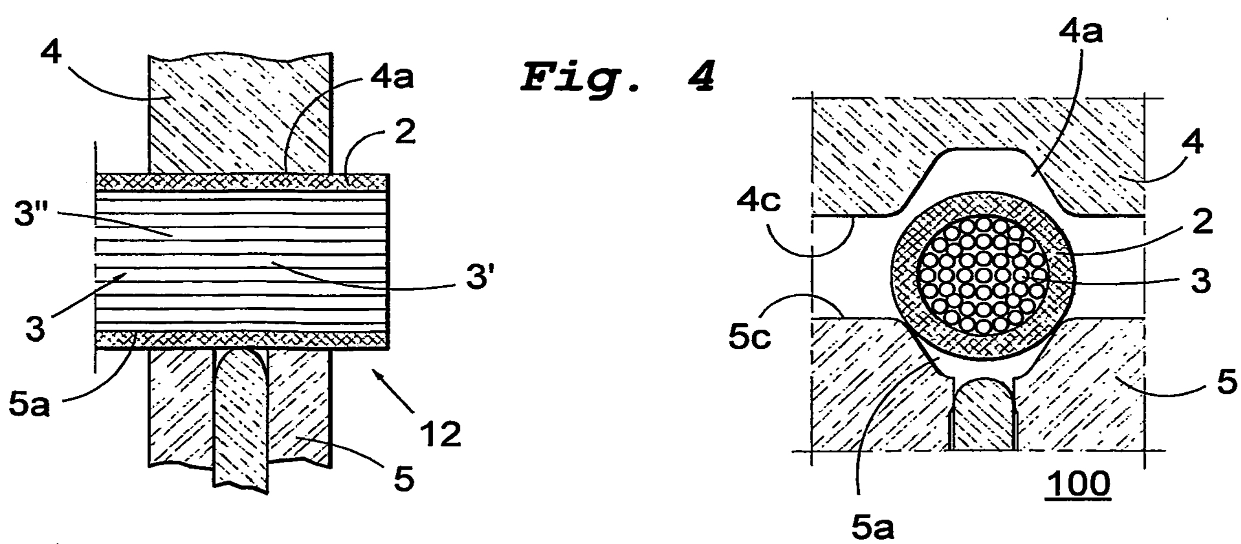



Fig. 4



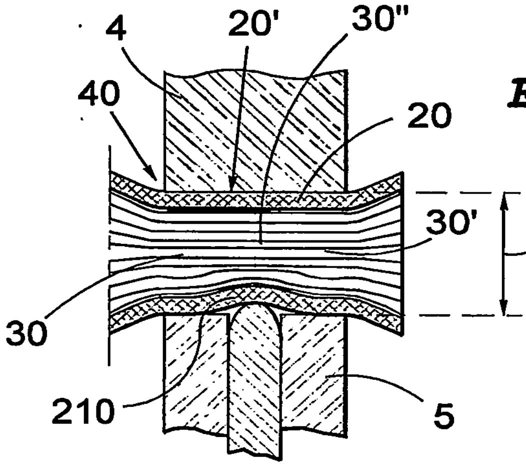
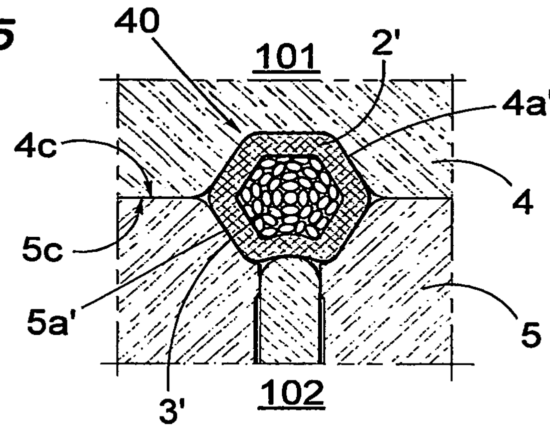



Fig. 5



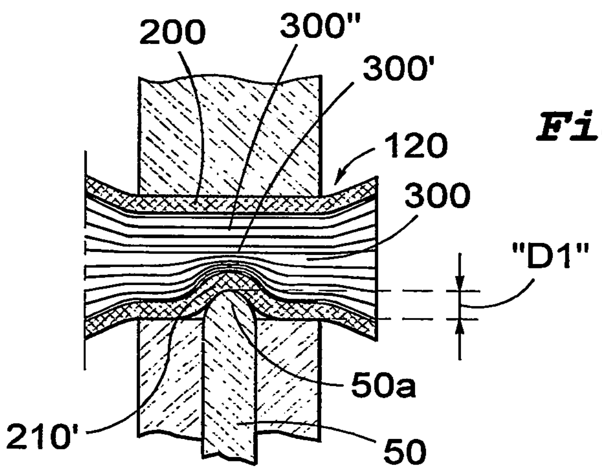
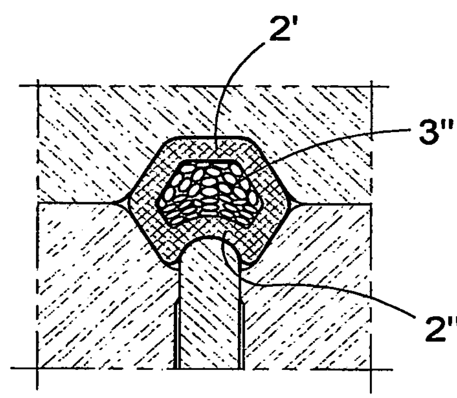




Fig. 6



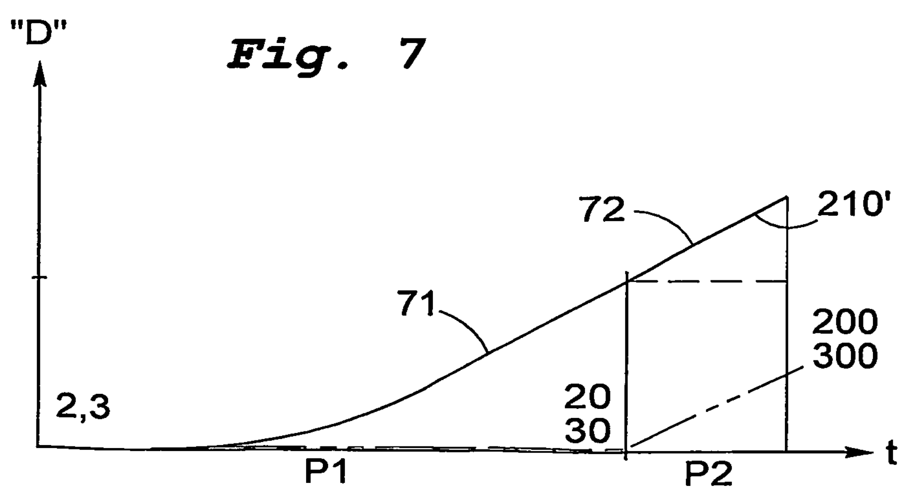




Fig. 7

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 02/02407

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC7: H01R 4/18, H01R 43/048

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | WO 9720363 A1 (THE WHITAKER CORPORATION), 5 June 1997 (05.06.97) -- | 1-26 |
| A | FR 2574994 A1 (ELECTRICITE DE FRANCE), 20 June 1986 (20.06.86) -- | 1-26 |
| A | DE 19906831 A1 (TYCO ELECTRONICS LOGISTICS AG), 14 Sept 2000 (14.09.00) -- -------- | 1-26 |

☐ Further documents are listed in the continuation of Box C.  ☒ See patent family annex.

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 11 March 2003 | 21-03-2003 |
| Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86 | Authorized officer Sara Thulin/MN Telephone No. +46 8 782 25 00 |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

30/12/02

International application No.
PCT/SE 02/02407

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| WO 9720363 A1 | 05/06/97 | US 5692294 A | 02/12/97 |
| FR 2574994 A1 | 20/06/86 | NONE | |
| DE 19906831 A1 | 14/09/00 | NONE | |